Chapter 8
Design References and Example

8-1. General

This chapter identifies wastewater treatment design manuals in which specific design criteria and examples can be found, and also lists design examples for small wastewater treatment plants not generally available in other references. These examples are not intended to be the only solution to the design of a small wastewater treatment facility in remote areas or for recreational purposes and are presented for information only. The purpose of this chapter (as well as Appendix E) is to provide the design engineer with the most up-to-date small-system wastewater treatment design information which has evolved since the latest Corps of Engineers engineering manual was published almost twenty years ago, and to emphasize earlier guidance which is still considered applicable. In identifying treatment methods applicable at recreational areas, design examples available in other military design manuals are referenced but not repeated herein. The treatment methods which follow are listed in the same general order as those methods discussed in Chapter 5.

8-2. Military Design Manuals

a. General. Design manuals which may be of assistance to the wastewater plant designer contain numerous examples outlining the approaches for collecting and analyzing the requisite information prior to the design phase of a project for both large and small wastewater facilities. A broad spectrum of design techniques, design considerations, and logical approaches are to be found in military publications.

b. USACE manuals.

(1) The most specific and current Corps of Engineers Manual, Army TM 5-814-3 (AFM 88-11, vol. 3), August 1988, provides general information, guidance and criteria for the design of domestic wastewater treatment facilities at permanent Army and Air Force installations located both in the United States and overseas. This manual discusses site selection; treatment requirements; basic design considerations; selection of treatment processes; small flow treatment systems such as septic tanks, waterless toilets, filtration/re-use systems, mound systems, Imhoff tanks, and package treatment plants; typical military wastewater treatment systems; plant layout; preliminary treatment; primary treatment; trickling filter plants; activated sludge plants; waste treatment ponds; advanced wastewater treatment; sludge handling; sludge treatment and disposal; disinfection (chlorination/dechlorination and ozone); flow measurement; sampling and process control; and considerations for both hot and cold climate operations.

(2) Design examples include: grit chamber; bar screen; proportional weir; Parshall flume; venturi flume; primary sedimentation; chemical precipitation; single-stage stone-media trickling filters and two-stage stone-media trickling filters; plastic media trickling filters; activated sludge (closed-loop reactor or oxidation ditch); microstrainer; multi-media filtration; activated carbon adsorption; phosphorous removal; nitrification-denitrification; anaerobic sludge digestion; aerobic sludge digestion; sludge pumping; gravity thickener; vacuum filtration; chlorination; and mound systems (pressure absorption fields for septic tanks). The manual includes pertinent design tables and accompanying figures.

8-3. National Small Flows Clearinghouse (NSFC) Publications

The NSFC was established in 1977 under the provisions of the Clean Water Act. In two decades of operation, the NSFC, funded by the U.S. Environmental Protection Agency and located at West Virginia University, Morgantown (1-800-624-8301; 304-293-3161), has become a national information source for small community wastewater treatment information. The engineering staff maintains extensive and comprehensive computer databases (bibliographic, facilities, regulatory, manufacturers and consultants, and state contacts). More than 250 books, brochures, case studies, database searches, and videotapes focusing on small community wastewater treatment issues are available; many are free, others no longer available from publishers are photocopied and priced on a cost-recovery basis. Of particular interest are treatment design manuals, septic tank pump pressure sewer systems (STEP) and design software for alternative sewers (pressure sewers, vacuum sewers, and small-diameter gravity systems). Selected references from NSFC were used to update this manual. For a complete list of publications, contact NSFC at the number listed above.

8-4. Wastewater Design Manuals and Texts

In the past decade, a number of comprehensive wastewater design texts and manuals have become available for designers and planners. The most recent publications, all of which are referenced in Appendix D, include:

- *Theory and Practice of Water and Wastewater Treatment*, Donald L. Droste, John Wiley & Sons, Inc., 1997 (Droste 1997).

- *Environmental Science and Engineering*, Second Edition, J. Glynn Henry and Gary W. Heinke, Prentice Hall, 1996 (Glynn 1996).

- *Unit Operations and Processes in Environmental Engineering*, Second Edition, Tom D. Reynolds and Paul A. Richards, PWS Publishing Company, Boston, Massachusetts, 1995 (Reynolds 1995).

- *Design of Municipal Wastewater Treatment Plants*, Volumes I and II, Water Environment Federation Manual of Practice No. 8 and ASCE Manual and Report on Engineering Practice No. 76, Book Press, Inc., 1991 (WEF MOP-8).

- *Wastewater Engineering Treatment, Disposal, and Reuse*, Metcalf and Eddy, Inc., Third Edition, revised by George Tchobanoglous and Franklin L. Burton, McGraw-Hill, Inc., 1991 (Metcalf & Eddy 1991).

8-5. U.S. Environmental Protection Agency (EPA)

EPA has kept current a series of wastewater-related design manuals, particularly in the following fields: wastewater treatment and disposal for small communities; alternative sewer systems; wetlands; land treatment; disinfection of wastewaters; biosolids/sludge handling, treatment and disposal. These publications, which are referenced in Appendix D, include:

a. Small communities.

"Wastewater Treatment and Disposal for Small Communities," EPA/625/R-92/005, September 1992.

b. Alternative sewer systems.

“Alternative Wastewater Collection Systems,” EPA/625/1-91/024, October 1991.

c. Wetlands.

“Subsurface Flow Constructed Wetlands for Wastewater Treatment,” EPA/832/R-93/008, July 1993.

“Water Quality Standards for Wetlands,” EPA/400/S-90/011, July 1990.

“Constructed Wetlands and Aquatic Plant Systems for Municipal Wastewater Treatment,” EPA/625/1-88/022, January 1988.

d. Land treatment.

“Land Treatment of Municipal Wastewater, Supplement on Rapid Infiltration and Overland Flow,” EPA/1-81/013a, October 1984.

“Land Treatment of Municipal Wastewater,” EPA/625/01-81/013, 1981.

e. Disinfection.

“Ultraviolet Radiation Technology Assessment,” Office of Water, EPA-832-R-92-004, September 1992.

“Design Manual Municipal Wastewater Disinfection Source,” EPA/625/1-86/021, October 1986.

f. Sludge/Biosolids.

“Surface Disposal of Sewage Sludges,” Office of Water, EPA, May 1994 (USEPA-5).

“Land Application of Sewage Sludge,” EPA/831-B-93-002b, December 1994.

“Biosolids Recycling,” Office of Water, EPA, June 1994 (USEPA-4).

“Domestic Septage Regulatory Guidance,” EPA/832-B-92-005, September 1993.

“A Plain English Guide to the EPA Part 503 Biosolids Rule,” EPA/832/R-93/003.

“Control of Pathogens and Vector Attraction in Sewage Sludge,” EPA/625/R-92/013, December 1992.

“Design Manual, Dewatering Municipal Wastewater Sludges,” EPA/625/1-87/014, September 1987.

8-6. Wastewater Design Criteria and Example Matrices

A series of matrices has been developed to assist the design engineer in quickly locating pertinent references for the design of selected wastewater treatment and disposal systems. The following topics are addressed in Appendix D:

Conventional Wastewater Treatment-Preliminary Sedimentation, and Biological Processes (Table D-1).

Sludge Handling, Treatment and Disposal (Table D-2).

Small Wastewater Treatment Systems (Table D-3).

Natural Systems Wastewater Design Criteria and Examples (Table D-4).

Effluent Disinfection and Individual Treatment Processes Design Criteria and Examples (Table D-5).

8-7. Additional Design Examples

A number of small plant designs, particularly for selected secondary treatment processes, are not addressed in the references cited in the matrices in Appendix D. These include package plants, oxidation ditches (carousel type), stabilization ponds, sequencing batch reactors, and zero discharge. Hence, the following small plant design examples (Appendix E) are presented for these processes:

a. Package plants (Extended-aeration activated sludge process). The design for a 124 900 L/d (33,000 gal/d) extended-aeration package plant is shown as Example E-1. The package plant is a stand-alone unit, requires no pretreatment, but is equipped with an effluent disinfection process.

b. Oxidation ditches (closed-loop reactors). Oxidation ditches, or CLRs, are considered a secondary treatment process and generally require pretreatment. A design example for a “race-track” shaped CLR is provided in TM 5-814-3, Appendix C, Paragraph C-8. As CLRs may be built in place or prefabricated, a design for a "carrousel" shaped facility to treat 379 000 L/d (100,000 gal/d) is provided as Example E-2.

c. Stabilization ponds. Stabilization ponds may be aerobic, facultative, or anaerobic, according to their oxygen profile. A 378 500 L/d (100 000 gal/d) stabilization pond with a primary clarifier and anaerobic digester of Imhoff Tank design with a secondary sand filter is given as Example E-3.

d. Zero discharge by recycle/reuse (closed-loop reuse). The closed-loop reuse principle is applicable to instances in which no liquid discharges from recreational treatment facilities are permitted or desired. After the system is initially filled and operational, any makeup wastewater from lavatories or drinking water fountains (estimated to represent about 6 percent of total water use) is allowed to evaporate from surface holding storage basins and the terminal holding pond or lagoon. Sludge is periodically removed from the surface holding storage basin. The design for a 37 900 L/d (10,000 gal/d) Zero Discharge Treatment Facility is shown as Example E-4.

e. Sequencing batch reactors (SBR). As stated in Chapter 5, the design of an SBR involves the same factors commonly used for the flow-through activated sludge system. If nitrification/dentrification and biological phosphorous removal are required, the SBR process must include pretreatment of the wastewater prior to the SBR reactor system. The design for a 379 000 L/d (100,000 gal/d) SBR treatment system is shown as Example E-5.

f. Constructed wetlands. The design of a 284 000 L/d (75,000 gal/d) aerobic non-aerated hyacinth constructed wetlands secondary treatment is shown as Example E-6.